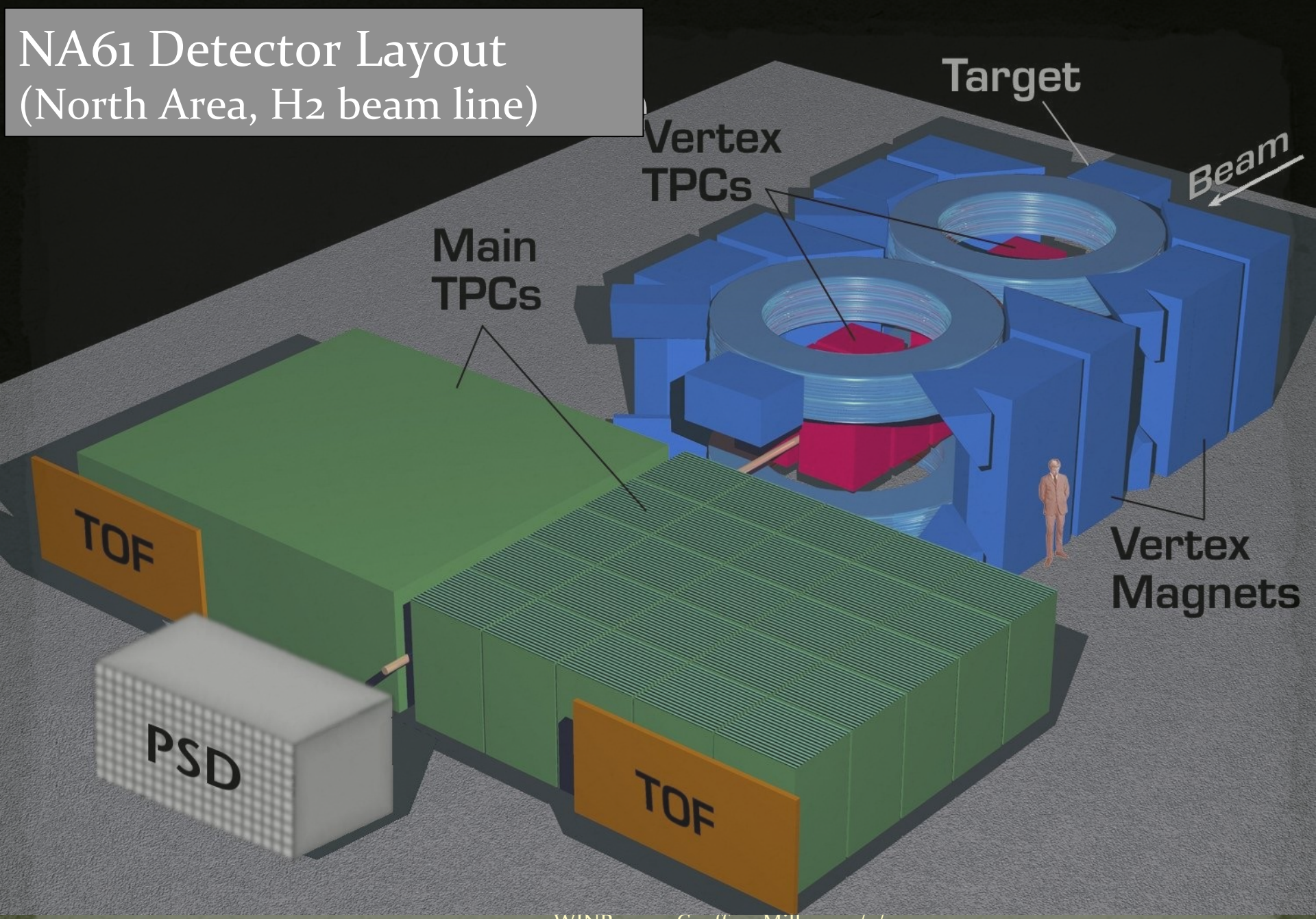
US-NA61 Hadron Production Measurements for the US Neutrino Program

Geoffrey Mills

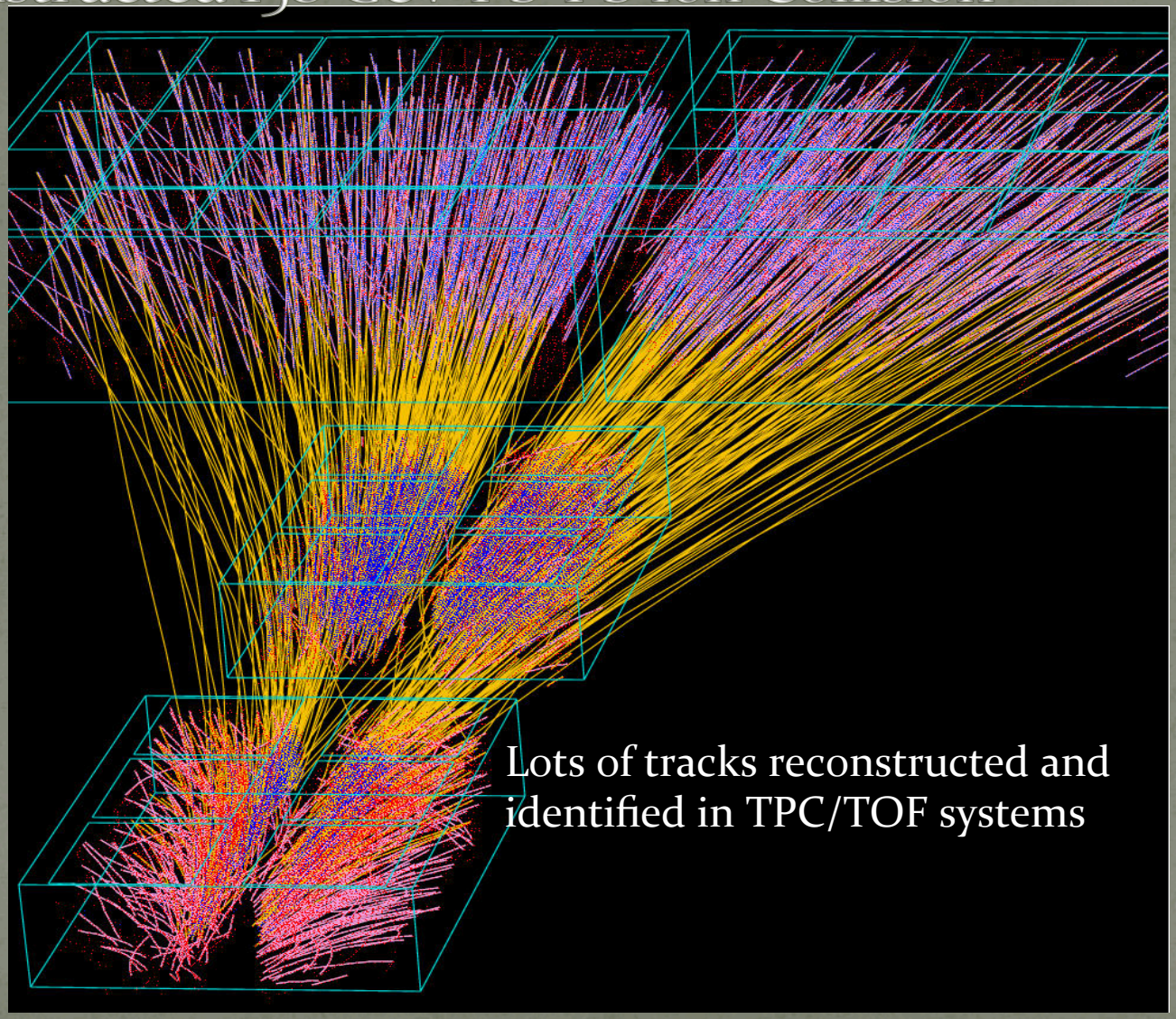
US-NA61 Proposal

- First discussions spring of 2012
  - The need for improved hadron production measurements is recognized, notable lack of πC interaction data
- Pilot run June-July 2012, 128 GeV pC
- 2012-2014 developed analysis capabilities
  - T2K analysis
    - not part of US-NA61, but overlap of people is large
  - USNA61 pilot run (2012)
- August, 2013 discussion with DOE on proposal
- Submitted in July, 2014
- Funded (DOE) for FY2015-FY2017
- CERN SPSC approval in fall of 2014

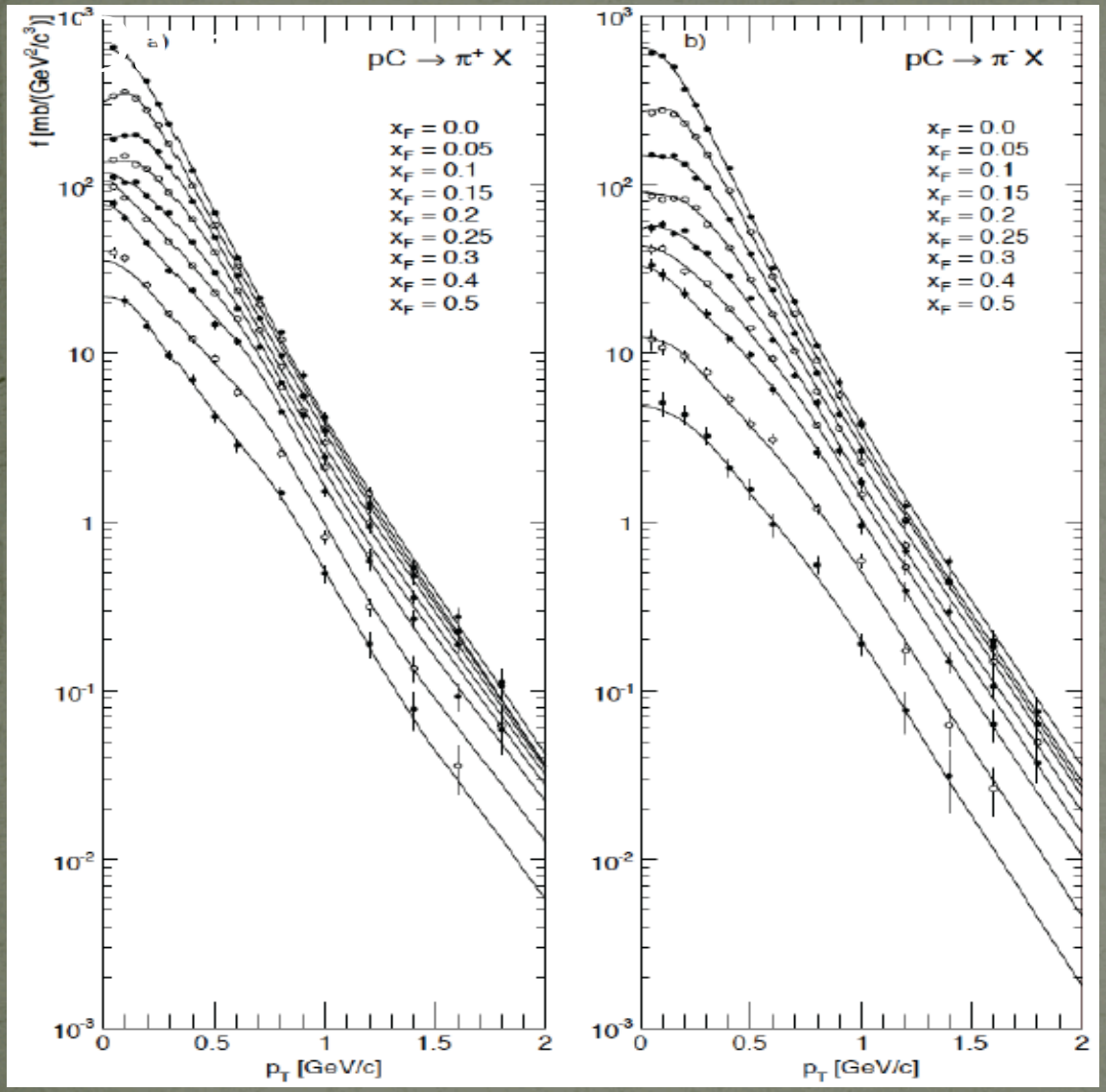
NA61 Detector Layout
(North Area, H2 beam line)

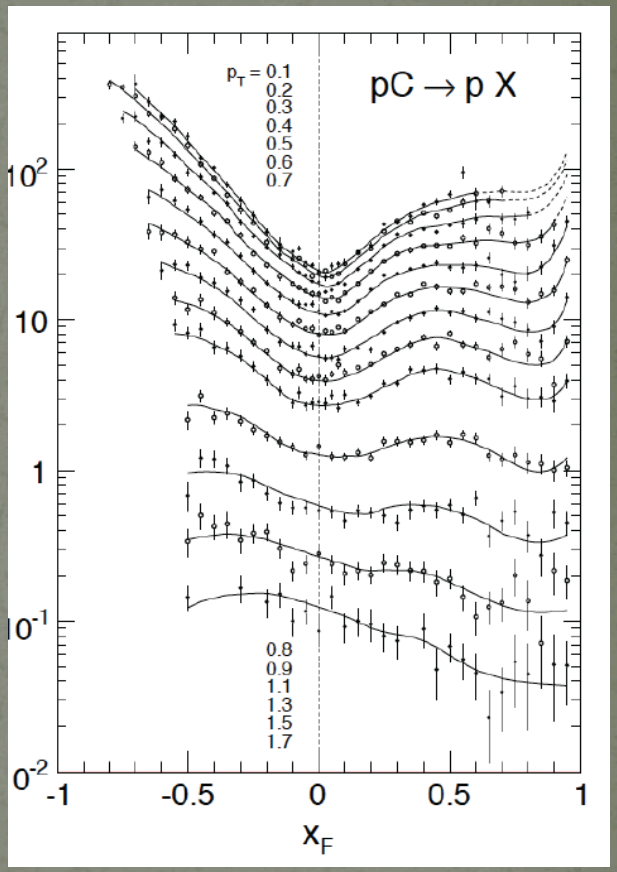


NA49: A Heavy Ion Collision Experiment
Reconstructed 158 GeV Pb-Pb Ion Collision

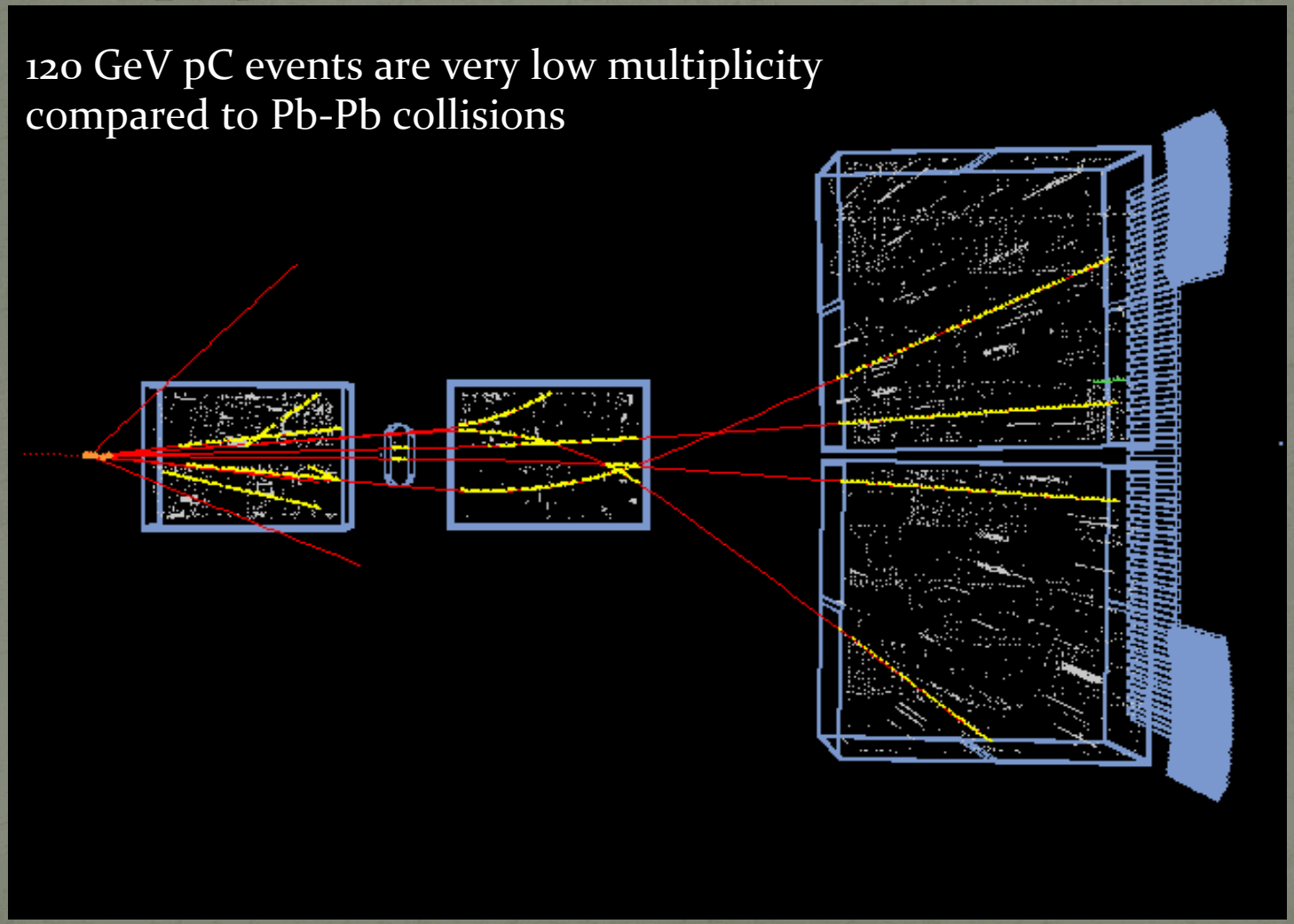


NA49 158 GeV Proton-Carbon pC->$\pi^{\pm}$,pX





Pilot Run Data:
Event Display for 120 GeV Proton-Carbon Interaction



Proposal

- Hardware Components
  - Organization
    - Geoff Mills
  - DRS4 electronics upgrade
    - Vittorio Paolone is responsible for ~65 motherboards
  - Forward Tracking TPC
    - Eric Zimmerman is responsible for the forward TPC mechanical structure, H.V. supplies (?)
- Goal: significant data runs in FY2015/2016
  - Analysis coordinator: Alysia Marino
  - First cross section results ~ early 2017

Proposal Submitted in July, 2014

Hadron Production Measurements

for Fermilab Neutrino Beams

US participation in the NA61/SHINE experiment at CERN

Proposal

July 23, 2014

Abstract

We propose to develop a collaboration with the NA61/SHINE experiment at CERN to exploit its powerful capabilities for particle production measurements. This effort would allow the US group to collect dedicated and optimized high-precision hadron production data needed to improve modeling of current and future Fermilab neutrino beams. We plan to expose both thin targets and replicas of targets used at Fermilab to the NA61 hadron beam to accumulate a large and comprehensive data set. An initial phase of this program is underway and is supported by existing funds. A group of US physicists participated in a pilot run during the start-up of the 2012 run of NA61, and also became integrated into the analysis effort centered at CERN. The pilot run used a 120 GeV/c proton beam on a thin graphite target, and the data set will provide valuable measurements for the MINERvA experiment. The current proposal is to add some modest hardware upgrades to the NA61 experiment in 2014 and 2015, and to execute a program of data runs in 2015 and 2016 that are designed specifically for enhancing the Fermilab neutrino program. Support for students and postdocs will be necessary to ensure the timely delivery of published cross-sections in an analysis effort over the next four years.

The US NA61 Collaboration

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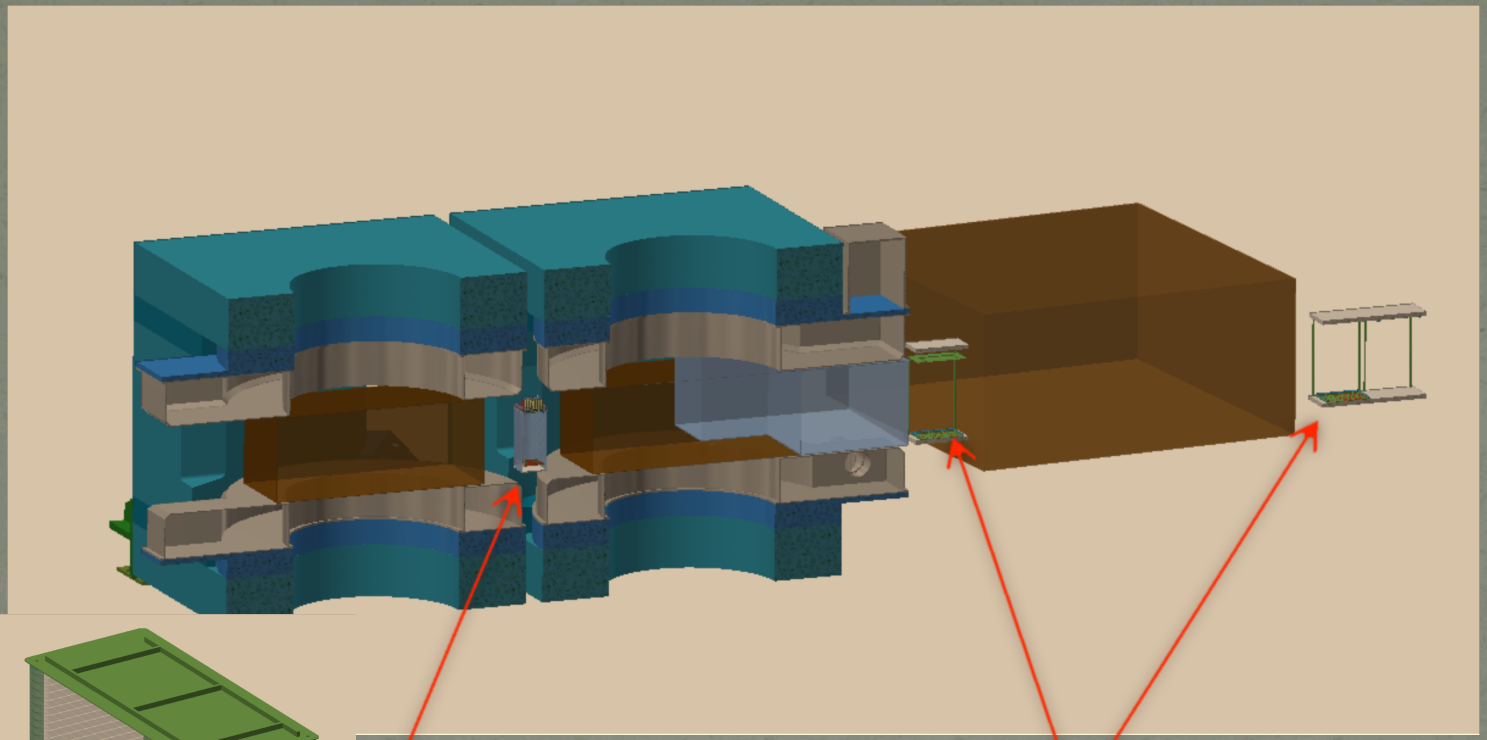
Funded FY14-17

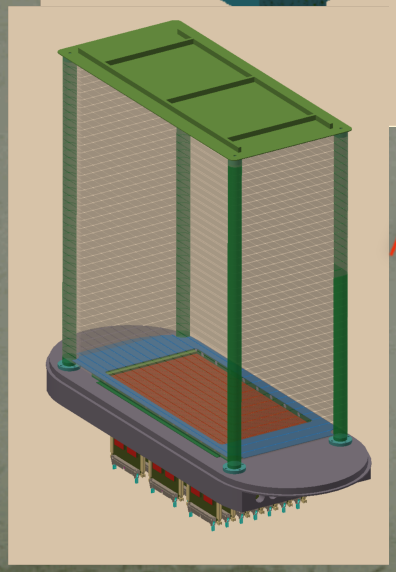
Hardware Contributions

- Electronics upgrade for TOF and beam counters (mother boards for ~3000 channels)
  - University of Pittsburgh (Vittorio Paolone)
  - 5 GHz waveform digitizer (DRS4 based)

- Forward TPC chamber mechanical construction
  - University of Colorado (Eric Zimmerman)
  - Covers gap in forward regions
  - Electronics already available

US-NA61 Forward TPC Design Progress





Possible locations for new FTPC

Existing GAP-TPC whose technology will be replicated.

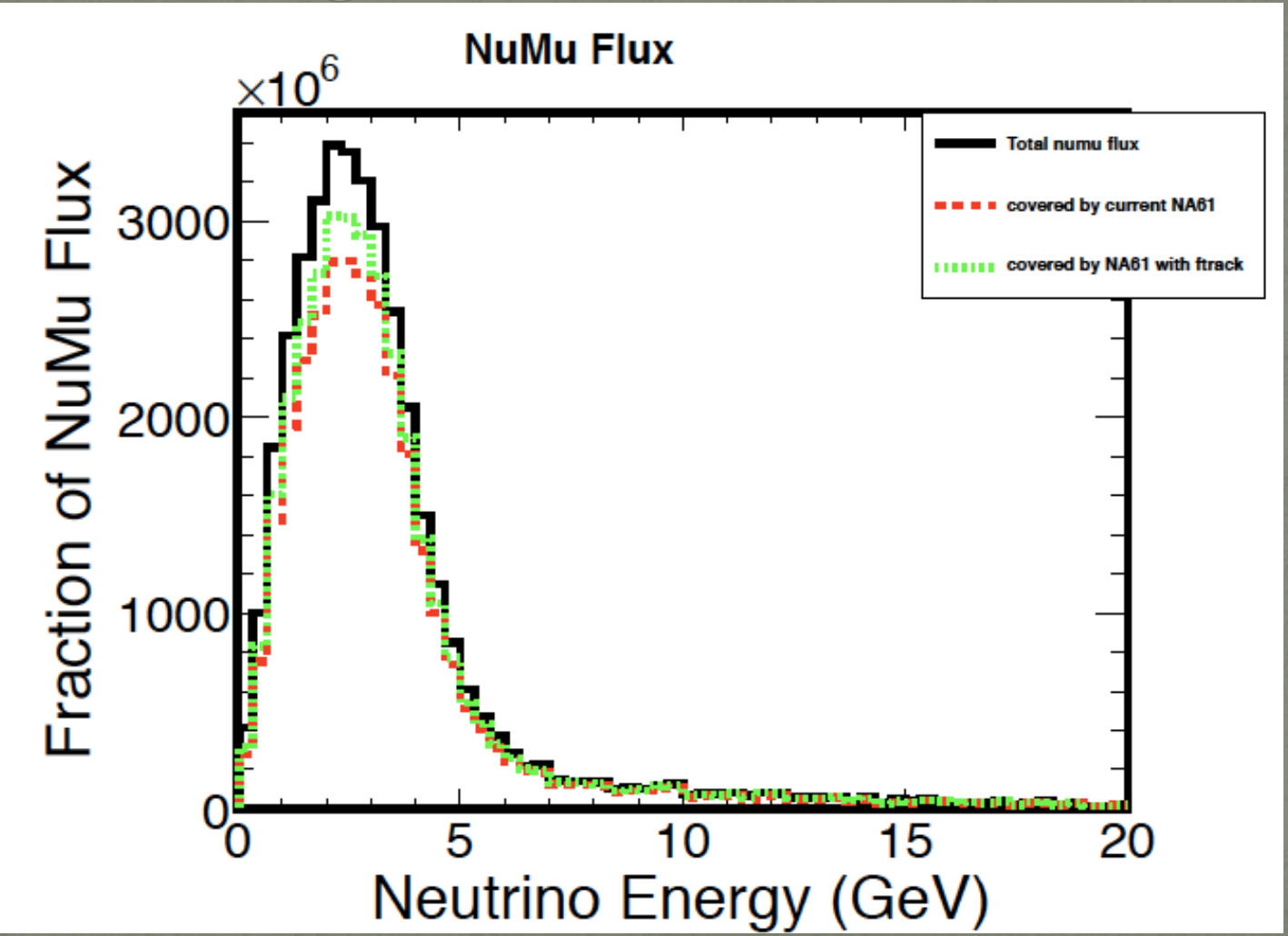
Thin Target Run Program: October 2015

proton+pion event totals	Incident proton/pion beam momentum		
Target	120 GeV/c	60 GeV/c	30 GeV/c
NuMI (spare) replica	(*future*)		
LBNE replica	(*future*)		
thin graphite ($< 0.05\lambda_I$)	3M	3M	(T2K data)
thin aluminum ($< 0.05\lambda_I$)		3M	(*future*)
thin steel ($< 0.05\lambda_I$)	(*future*)	(*future*)	(*future*)
thin beryllium ($< 0.05\lambda_I$)	3M	3M	(*future*)

Summary

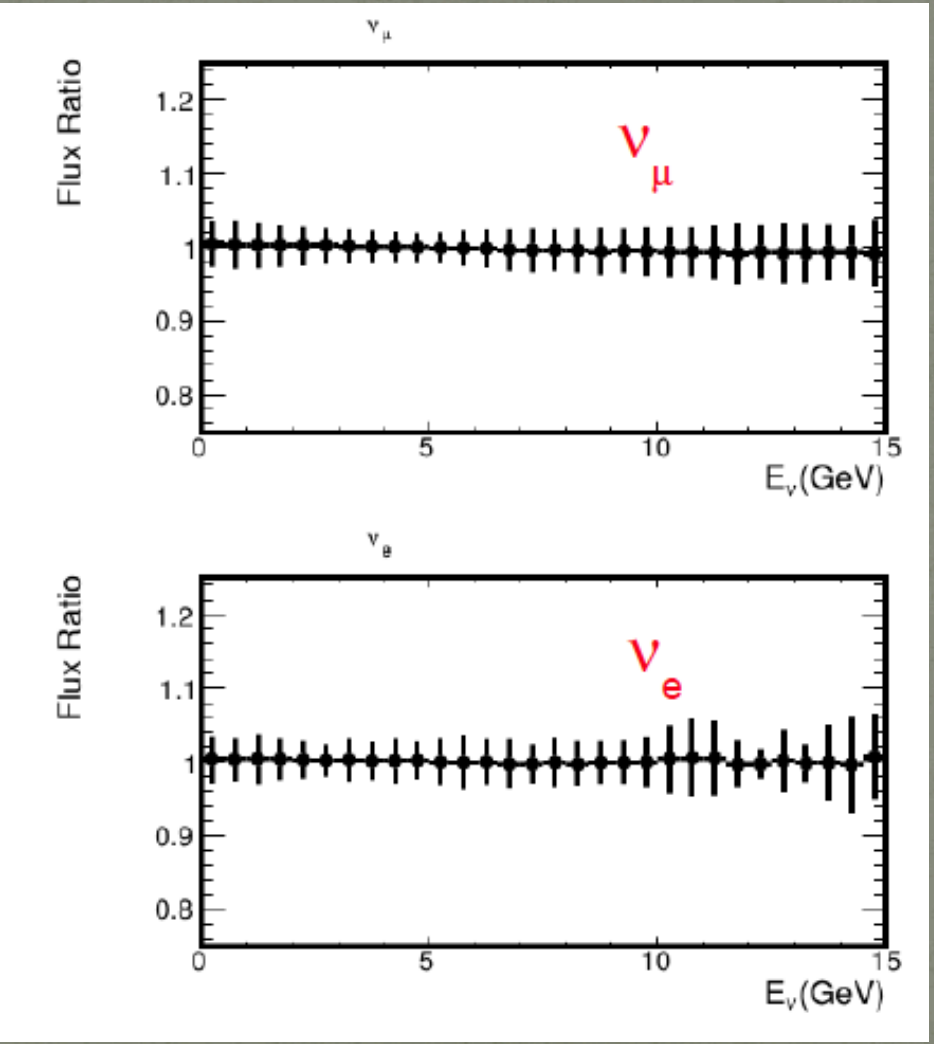
- Program to make high quality hadron production measurements with the NA61 (formerly NA49) spectrometer for the Fermilab NuMI (current) and LBNE (future) beams
- Proposal has been funded FY14-17
- Hardware upgrades in the design stage, expect installation in FY2016
- First thin target data run in October 2015

NA61 Coverage of LBNE Flux Sources

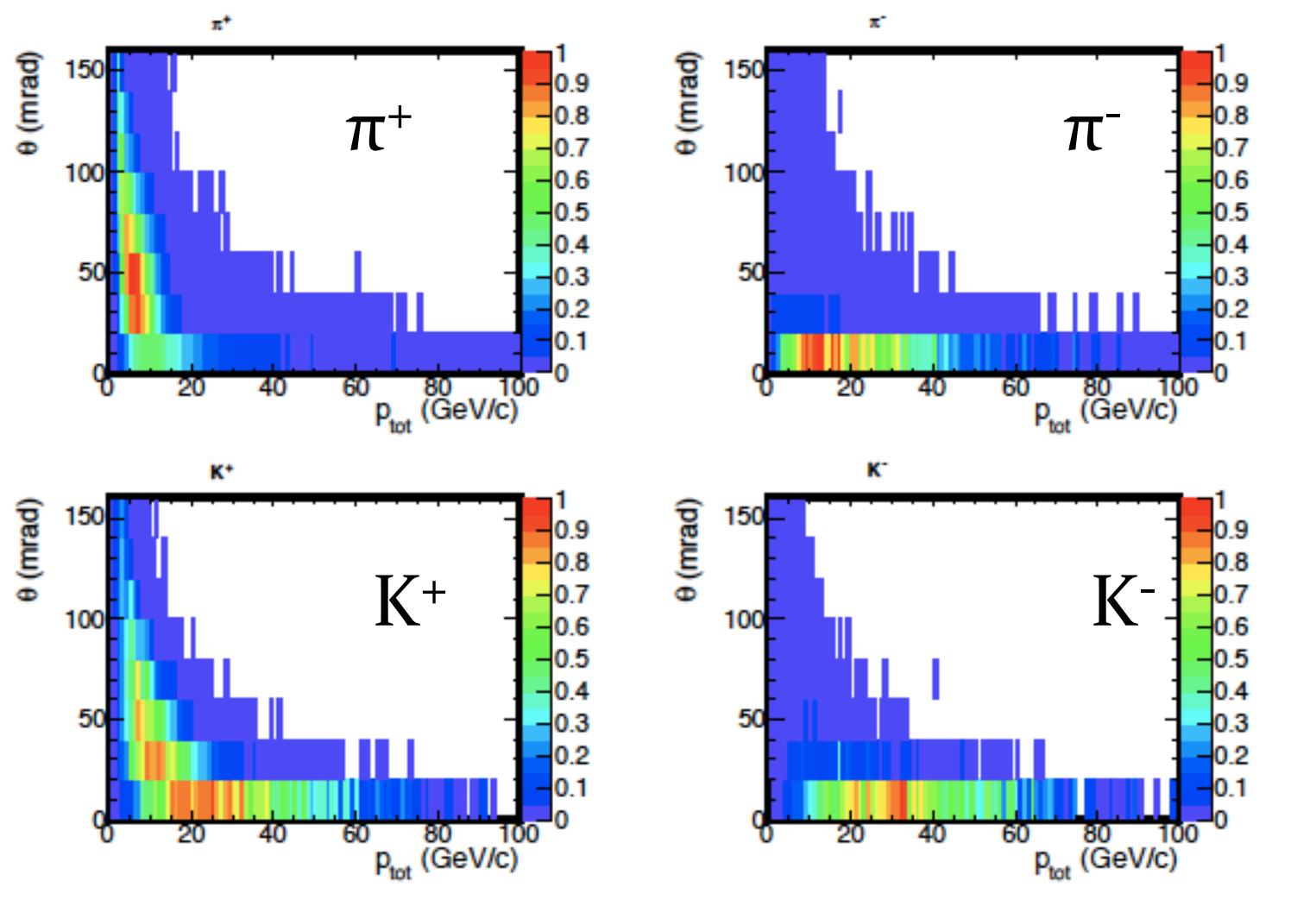


Systematic Error Fluctuations due to Hadron Production Cross Section Uncertainties with USNA61 Measurement Errors

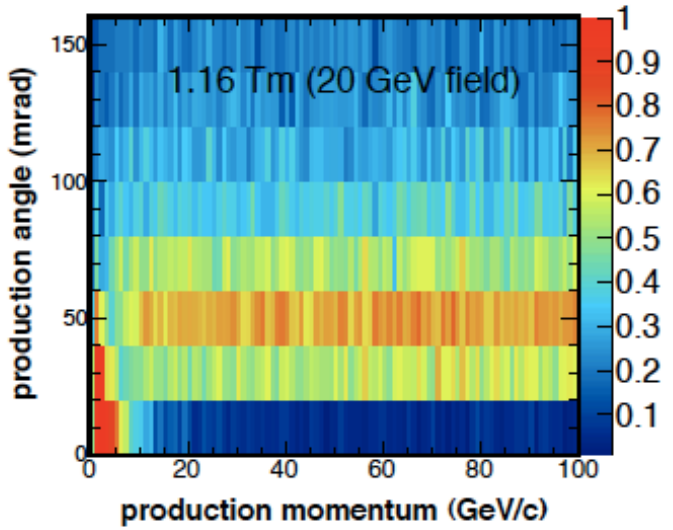
Ratio to nominal FD flux

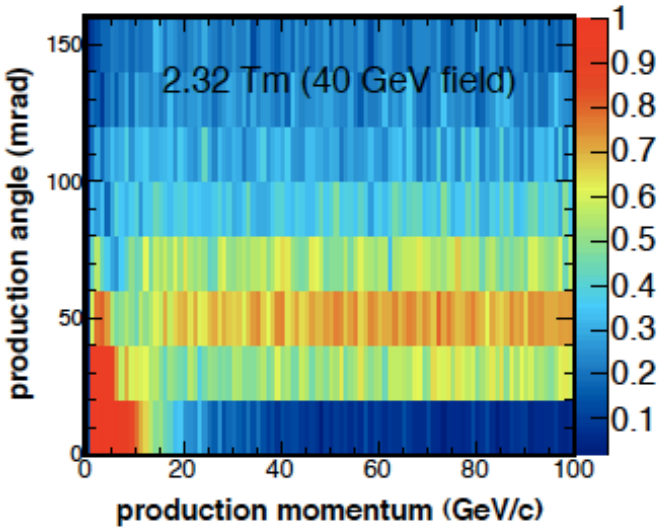


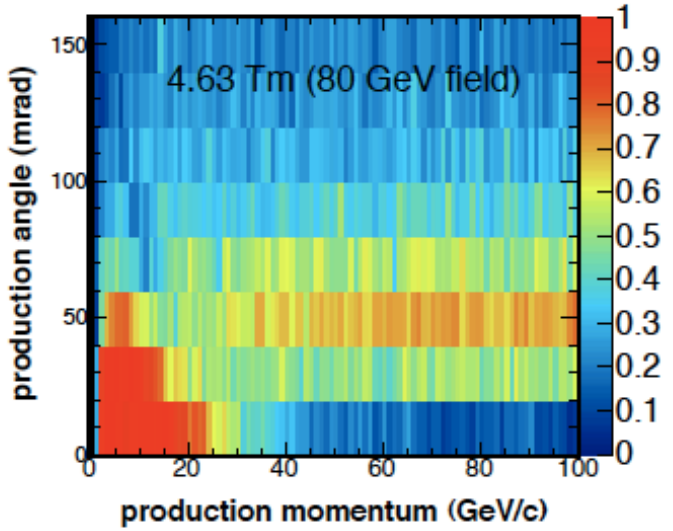
Particles Leaving Target Weighted by Neutrino Flux

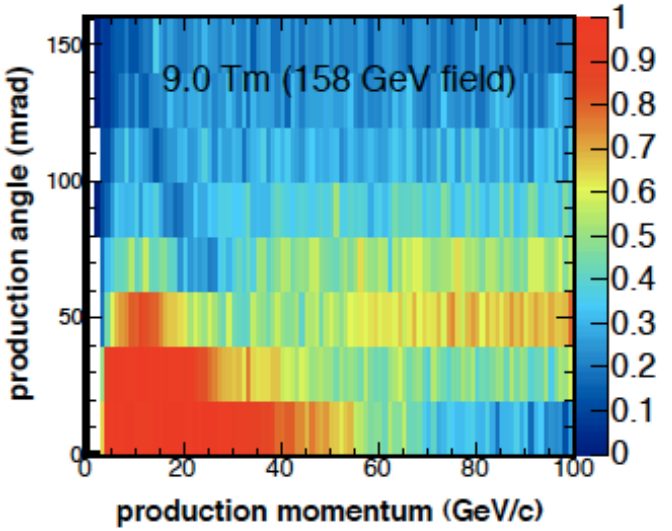


NA61 Acceptance









FTPC Acceptance